

## **Electronic supplementary information**

# **Quantitatively controllable fluid flows with ballpoint-pen-printed patterns for programmable photo-paper-based microfluidic devices**

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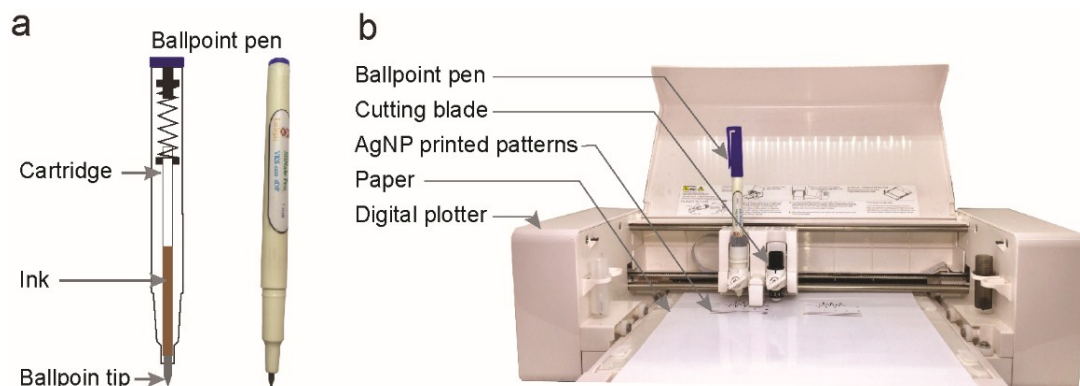
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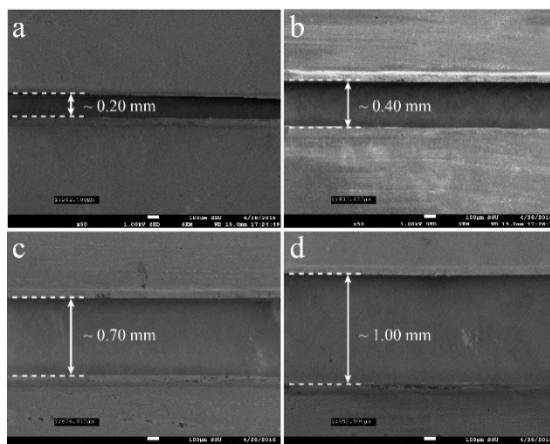
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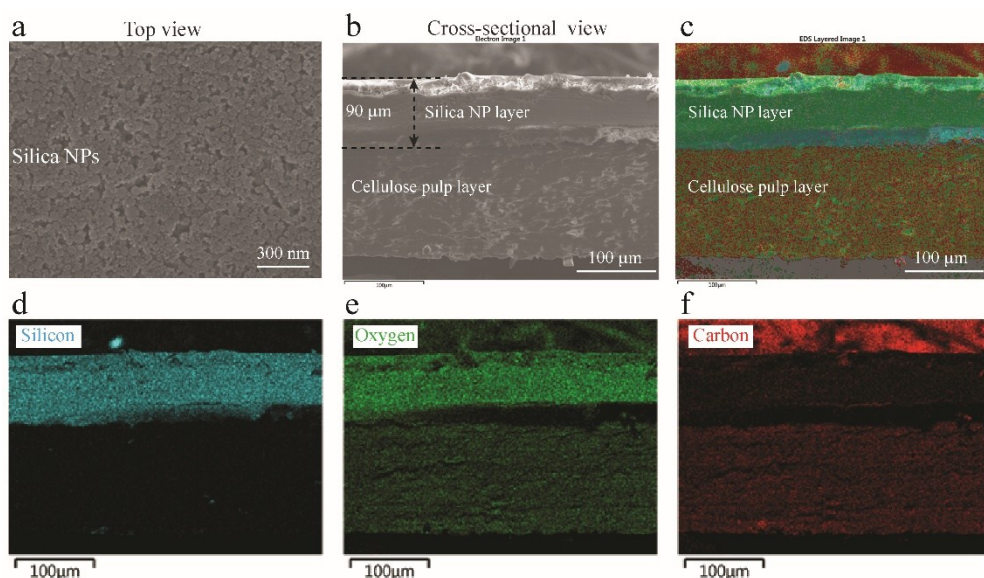
\* Email: kwshin@sogang.ac.kr.



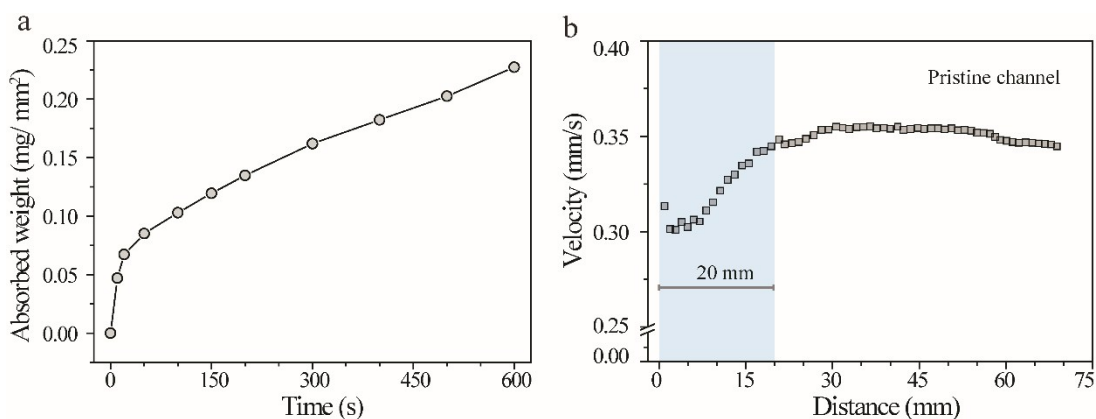
**Fig. S1** (a) Schematic illustration of structure of a ballpoint pen and a prepared ballpoint pen. (b) A photograph of a digital plotter that was used for the fabrication of a programmable photo-paper-based microfluidic device. It was mounted by a ballpoint pen and a cutting blade for printing the patterns and cutting the microfluidic channel and the cover, respectively.



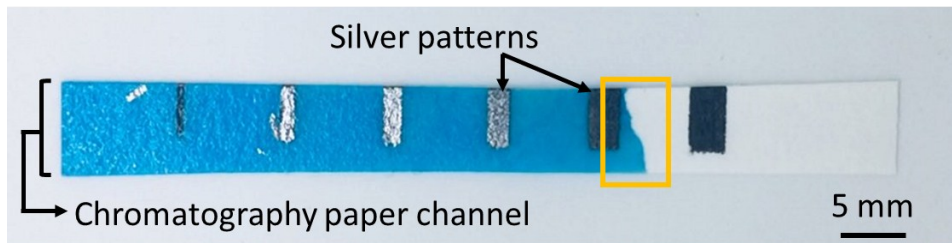
**Fig. S2** Cutting resolution of the guided channels. (a – d) are cut channels with various widths.



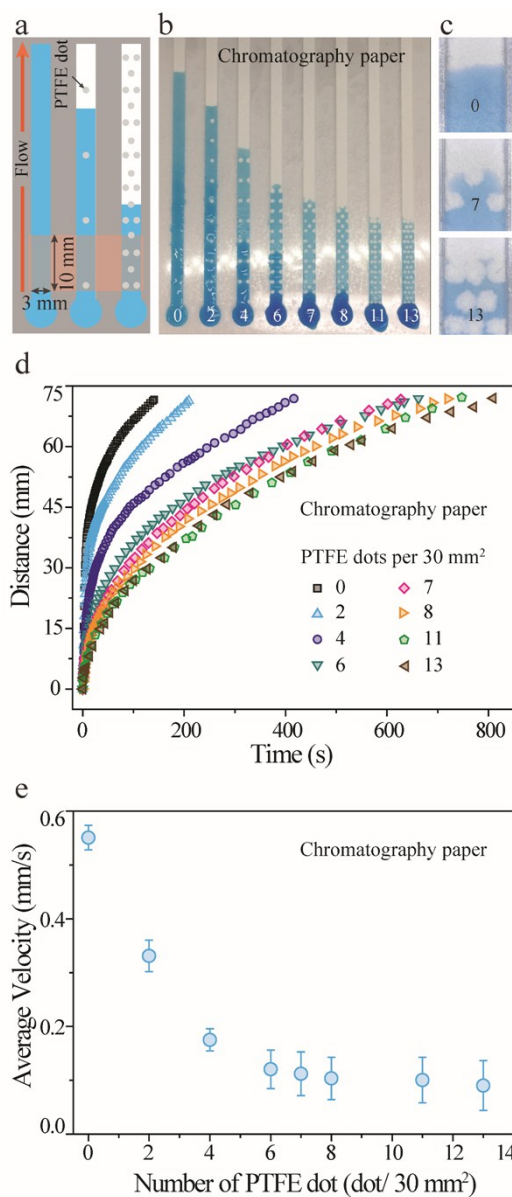
**Fig. S3** Surface properties of photo paper. **(a)** Scanning electron microscopy (SEM) image of the photo paper at the top view and **(b)** the cross-sectional view. **(c-f)** are composition analysis by energy dispersive spectroscopy (EDS) of photo paper of **(b)**.



**Fig. S4** **(a)** Weight of water absorbed into the photo paper matrix versus the immersion time. **(b)** Fluid velocity versus distance in a 3-mm-wide, 70-mm-long photo-paper-based channel.



**Fig. S5** Reduced fluid transport velocity when passing through printed AuNP lines on a chromatography paper channel.



**Fig. S6** Reduced fluid flow velocity caused by the printing of PTFE dots in the chromatography paper channels: (a) schematics and (b) microfluidic channels modified by using various numbers of PTFE dots along the channels. (c) Photographs of the menisci of the fluid in the channels. (d) Position of the meniscus versus time of travel in the channel and (e) average velocity of the fluid versus the number of PTFE dots.